MUSE integral field unit observations of the compact objects in the globular cluster NGC 6397

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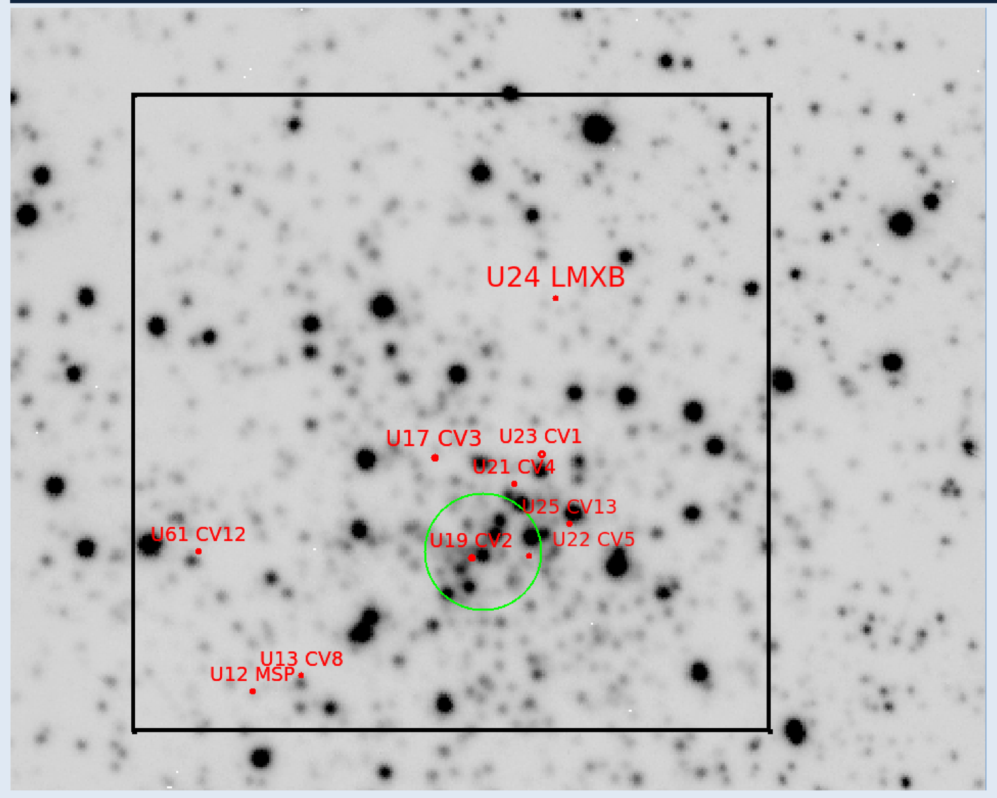
Abstract

Globular clusters are very old groups of stars. Due to their age and the gravitational interactions dominating the dynamics of the clusters, they are home to a significant fraction of compact binaries. The formation and evolution of these kinds of binaries is still not completely understood. Of special interest is the globular cluster NGC 6397 as it is the closest core collapsed cluster and has therefore been extensively studied with instruments like Chandra, Hubble Space Telescope, and more recently in the optical with the Multi Unit Spectroscopic Explorer (MUSE), installed on the Very Large Telescope (VLT). Integral field spectrographs, like MUSE, have many advantages compared to traditional long slit spectroscopy, as spectra are obtained for every pixel and thus every object in the large field of view (1' x 1'). Here we present analysis of the compact binary population in NGC 6397 taken with MUSE. The goal is to further understand the characteristics of the proposed bimodal population of cataclysmic variables in the cluster, which have been suggested to be of primordial and dynamically formed origin. Spectral analysis will allow us to examine the origin of these two populations.

Goals

- Identify bimodal cataclysmic variable (CVs) population in NGC 6397: Primordial vs Dynamically formed
- Explore mass ratio to Hα line relation in globular clusters CVs
- Identify possible magnetic candidates: Magnitude variability, presence of Helium lines and Hβ equivalent width

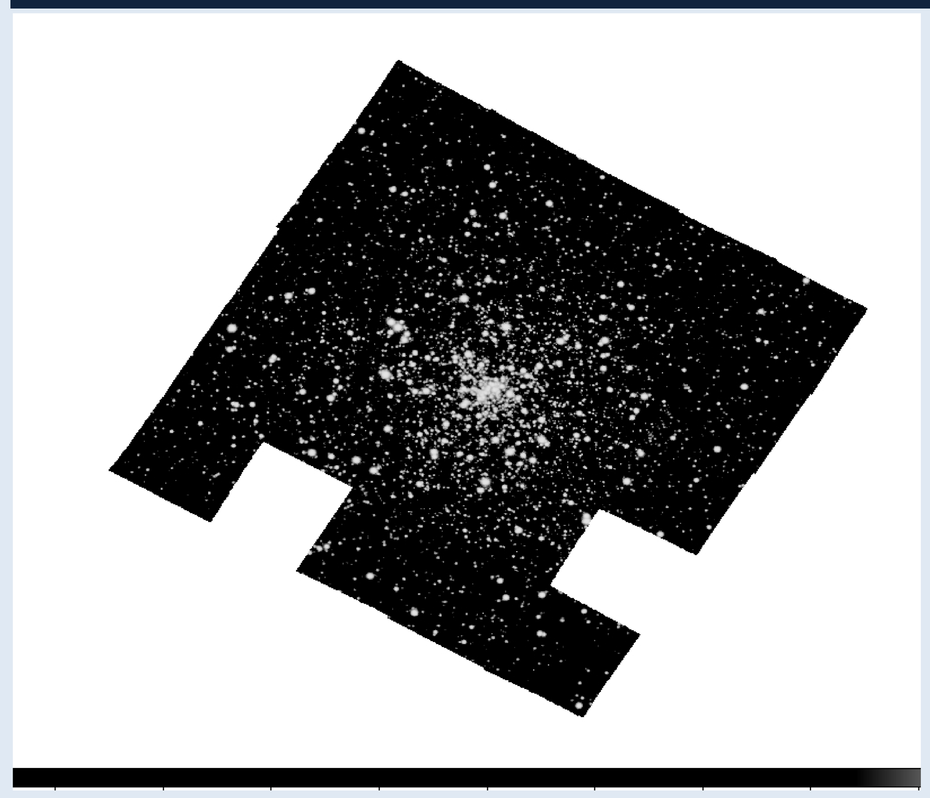
MUSE



- Integral-Field Spectrograph [1]
- Range of 480-930 nm
- 1' X 1' FOV
- 0.2" spatial resolution
- 1750 (480 nm) to 3750 (930 nm) λ resolution

Fig. 1 MUSE (Bacon et al. 2014) exposure of the central region of NGC 6397. The black square represents the 1' FOV and the green circle the core radius. Each of the red points corresponds to a compact object (Cohn et al., 2010).

NGC 6397



- 2.3 kpc (Harris, 1996)
- 15 CV candidates
- Only 4 spectroscopically confirmed
- All 4 CVs proposed to be magnetic.
- 5 AM CVn candidates
- 1 qLMXB
- 2 MSPs
- 0.05' core radius [5]
- 2.9' half-light radius [5]

Fig. 2 Mosaic of MUSE data (127 exposures and 95 minutes of integration time), taken in 2014.

The two new spectra

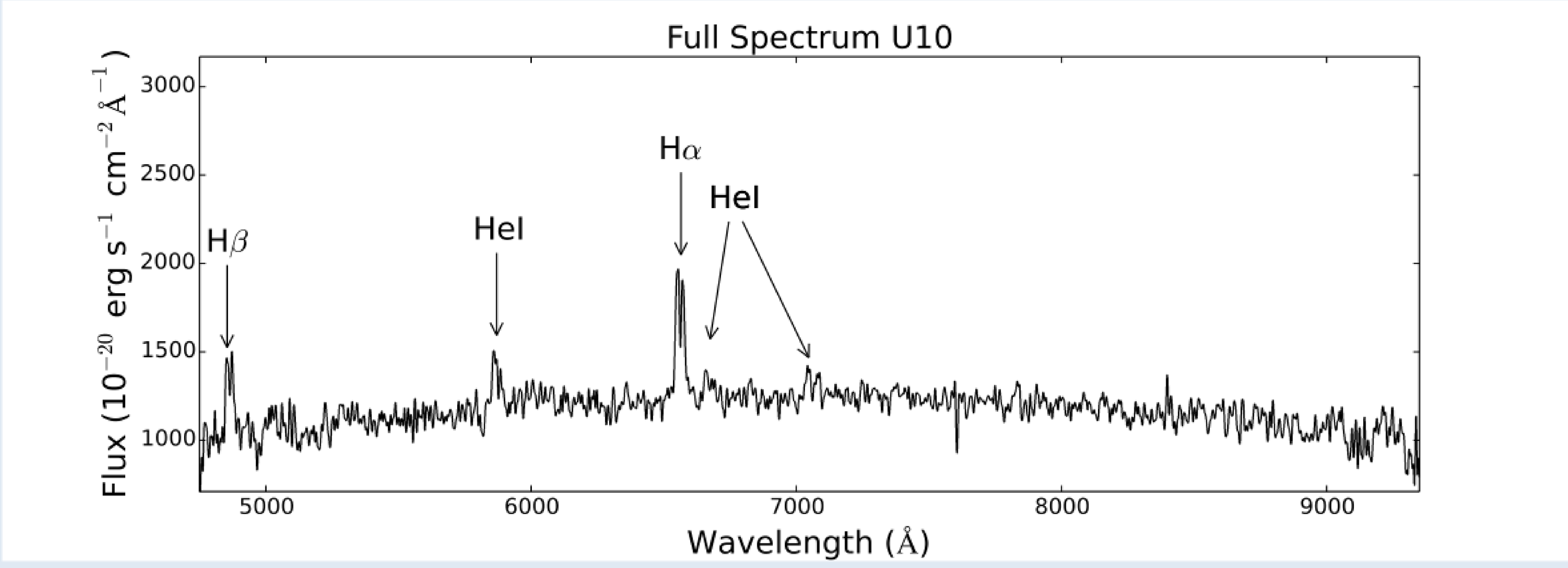


Fig. 3 Spectrum of U10 with strong Hydrogen double peaked emission (characteristic of an accretion disk), and strong Helium I lines.

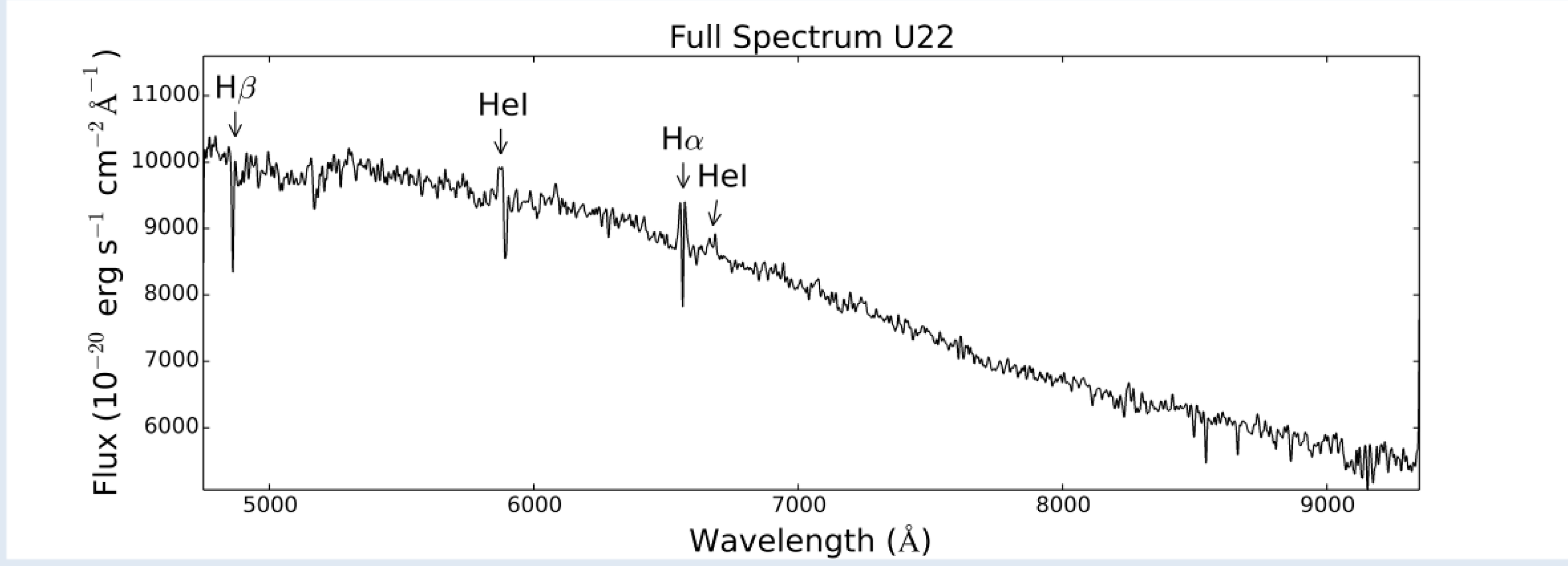


Fig. 4 Spectrum of U22 with strong Hα double peaked emission, absorption in the Hβ line, and Helium I lines.

U23, U21, and U10

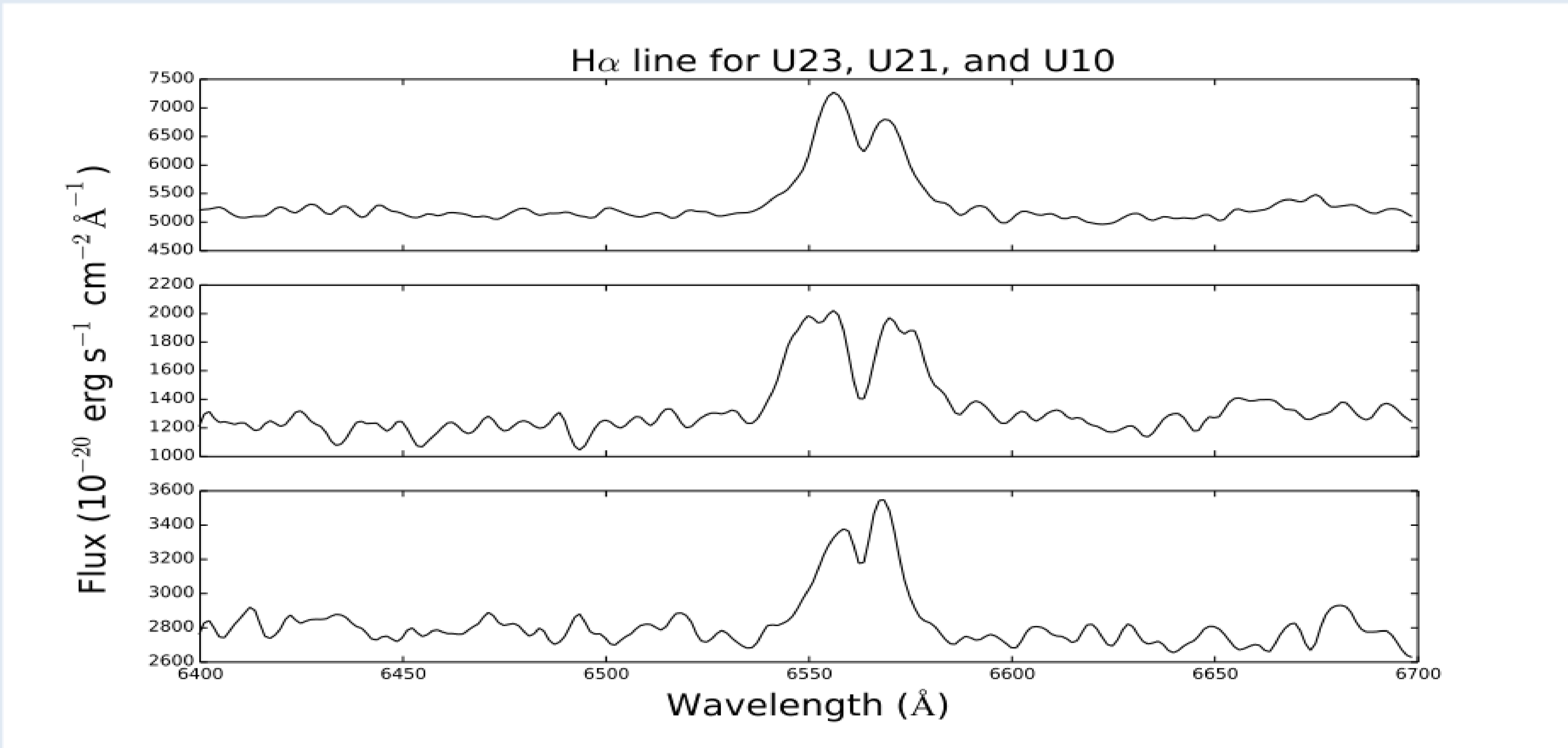
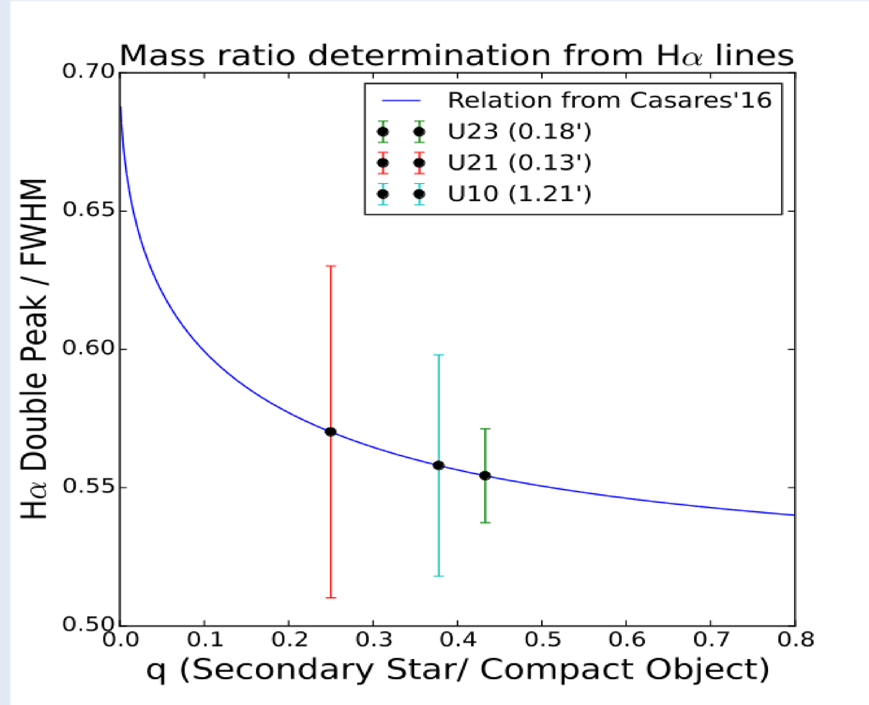


Fig. 5 Zoom of the spectra around Hα for U23 (top), U21 (middle), and U10 (bottom).

Mass ratio determination



- Mass ratio from Hα (see Casares, 2016)
- Correlation is explained by the 3:1 resonance with companion star
- Correlation dominates for extreme mass ratios
- We expect a bias for high mass companion for dynamically formed CVs near the center

Fig. 6 Relation between the ratio of Hα double peak separation to FWHM and the mass ratio (companion star over white dwarf mass) from Casares 2016. The value in parenthesis is the projected distance to the cluster center. q for U23 is 0.433, for U21 is 0.25 and 0.3 for U10.

Results and Discussion

- Two new spectrally confirmed CVs (U10 and U22). U10 at a distance of 1.21' from the cluster center
- Presence of helium lines in all detected CVs and comparable Hβ EW. They are all possibly magnetic
- No signature of M star in the CVs spectra. Possible K type star companion (0.54 – 0.9 $M_\odot$) (Gray, 2005)
- The lower limit for a K type star companion gives a minimum white dwarf mass of 1.04 $M_\odot$ for the highest q found
- The CVs show small magnitude variability between MUSE (2014) and Hubble observations (2004-2005) (∽1-2 magnitudes)

References

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